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Andreas Breiter and Juliane Jarke

Datafying education: How digital assessment practices reconfigure the organisation of learning

Forschungsverbund „Kommunikative Figurationen“ | Research Network “Communicative Figurations”
Universität Bremen | University of Bremen
ZeMKI, Zentrum für Medien-, Kommunikations- und Informationsforschung
Linzer Str. 4, 28359 Bremen, Germany, E-mail: zemki@uni-bremen.de
www.kommunikative-figurationen.de | www.communicative-figurations.org

Andreas Breiter (abreiter@uni-bremen.de)
Since July 2008, Dr. Andreas Breiter is full professor for Informatics in the Department for Mathematics and Computer Science at the University of Bremen. He is scientific director of the Institute for Information Management Bremen GmbH, a not-for-profit research center at the University of Bremen (www.ifib.de). He is co-chair of the interdisciplinary Centre for Media, Communication and Information Research of the University of Bremen (http://www.zemki.uni-bremen.de/english/home.html). From 2004 to 2008 he worked as Assistant Professor (Juniorprofessor) at the University of Bremen. During his PhD in Applied Informatics in 1997 to 2000, he joined the Telecommunications Research Group where he worked as a senior research associate (2000-2004). 2002 he was Visiting Scholar at Columbia University (New York City) and at the Center for Children and Technology. Andreas Breiter studied Sociology, Informatics und Law at the Goethe-University in Frankfurt/Main und at the University of Southampton (UK). For two years (1995-1997) he joined the Fraunhofer-Institute for Systems and Innovation Research in Karlsruhe.

Juliane Jarke (jarke@uni-bremen.de)
Dr. Juliane Jarke is a researcher at the Institute for Information Management Bremen GmbH (ifib) and at the Centre for Media, Communication and Information Research (ZeMKI) at the University of Bremen since September 2014. Prior to Bremen, she worked as a research associate at the Centre for the Study of Technology and Organisation at Lancaster University (2013-2014). Juliane Jarke holds a PhD in Organisation, Work and Technology, an MSc in Information Technology, Management and Organisational Change (both from Lancaster University) as well as an MA in Philosophy and a BSc in Informatics (both from the University of Hamburg). Juliane Jarke’s research intersects the boundaries of Organisation Studies and Information Systems Research. Conceptually she draws on Science and Technology Studies (STS), and in particular Actor-Network Theory (ANT). Her main research interests focus on the ways socio-technical systems work and are made to work by looking at the interactions of people, technologies, organisation and practice. Currently Dr. Jarke is leading a workpackage on Participatory Design in Civic Technology and Open Data in the EU-funded research and innovation action MobileAge.

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1 Introduction

In the past decade, an ever increasing trend to capture (social) life in numbers became a prominent instantiation of the so-called ‘audit society’ (Power 1999). With this turn, almost all aspects of social life have become measured and quantified. This datafication of social life raises expectations concerning increased transparency, accountability and civic participation but also associated fears with respect to surveillance, privacy issues, a data literacy divide and control (Kitchin 2014; Borgman 2015; Gitelman 2013). Datafication as a trend of a changing media environment affects many social domains significantly, and one of the most noticeable of these are organisations of education (Piety 2013). It relates for example to schools’ performances and student achievements which are compared on a national and international scale; it may affect salaries of teachers and school managers which are adjusted according to test scores as well as decision-making of parents for school choice or communication and control of teachers.

Assessments have always been decisive features of learning and are pervasive within education: School exams evaluate pupils; achievement tests measure and select students for higher education, school performance studies such as PISA measure and compare whole educational systems. With the ever growing use of information and communication technologies to support the organisation of learning and teaching new devices for monitoring, evaluating, and ranking the performance of individual learners and of educational institutions/systems have become available. They range from computer-based tests to learning analytics on large-scale data in complex information systems. They allow the ‘recording, storage, manipulation and distribution of data in digital form’ (Selwyn 2015: 64). Digital data are distinct from pre-digital forms as they may be exhaustive in scope, highly detailed and can be combined in a flexible manner and at different aggregation levels, bringing together ‘datasets of different times, from different places or gathered at different times’ (Parks 2014: 356). Such possibilities have always existed on a small scale, but new data infrastructures for accountability (Anagnostopoulos et al. 2013) and algorithmic capabilities allow for analytics on an ‘unprecedented complexity and scope’ (Parks 2014: 356). Within the educational context, more data and more heterogeneous data are being generated—deliberately—for monitoring, surveillance or evaluation purposes but also—automatically—through routine operations of digital devices and systems (Selwyn 2015: 65).

Educational information infrastructures allow for ‘pervasive forms of data work’ (Selwyn 2015: 66) across regional and national educational systems and cover almost all aspects of the organisation of education (from budgeting and staffing to national student databases and the processing of examination results, to rankings of school performance or school inspection reports).

Overall such assessment and ranking activities have become key aspects of national and international educational policy-making and demonstrate the ‘political significance of educational data’ (Selwyn 2015: 66). The underlying goals range from school improvement plans to accountability systems (Anagnostopoulos/Rutledge/Jacobsen 2013). In particular, through so-called 'big data' has the governance of education been framed within a discourse of 'evidence-based decision making' or 'digital governance'. Williamson (2015) speaks of 'governing software' and the 'emergence of "digital governance" in public education' (2015: 83). He argues that educational decision-making is increasingly being delegated to database-driven analytics software and states that 'software has now become a significant social actor that can govern and shape people's lives' (Williamson 2015: 85).

Espeland and Sauder (2007: 10) demonstrated that 'rankings are reactive because they change how people make sense of situations'. Different ranking devices afford particular kinds of ranking. Such rankings 'do more than simply describe a setting but […] also intervene within a situation' (Pollock 2012: 94, emphasis in original). It is important to consider how ranking devices (including the information infrastructures through which they are enacted) come to be configured and how in turn 'rankings shape settings' (Pollock 2012: 94). Hence, such evaluation technologies are not inert but performative and participate in the construction of social domains such as education.

In this paper we argue that evaluations are not just a social process but a practice that is thoroughly material as well: Digital assessment practices concerned with education may be described as 'material-discursive practices' (Barad 2007) that shape and reconfigure the organisation of learning. Educational information infrastructures connect actors and configure associations across the different aggregation levels of assessment, meaning- and decision-making. It is hence important to understand the performative conditions that information infrastructures afford to the assessment of education. Through the study of digital assessment practices are we able to trace those connections and make the datafication of education and the associated reconfiguration of the organisation of learning visible.

The paper is structured in the following way: First we will give a brief introduction into our theoretical framework. We will then consider a number of examples/case studies in which digital assessment practices reconfigure the organisation of learning differently. A discussion section will set these different configurations in relation and critically review the ways in which they are participating in meaning- and decision-making, and ultimately how they matter.

2 Theoretical Framework: The sociomateriality of digital assessment practices

When considering the role of digital assessment practices for the organisation of schooling it is important to reflect on how data may be conceptualised. Scholars engaged in so-called 'critical data studies' argue that data do not just exist but rather that data are 'generated' (Manovich 2013; Gitelman/Jackson 2013): Despite familiar processes of data definition, data collection, data compiling, data storing, data processing, data mining and data visualisation, an important aspect in each of these processes are practices associated with the interpretation of data. Gitelman and Jackson (2013) argue that 'data need to be imagined as data to exist and function as such, and the imagination of data entails an interpretive base' (2013: 3, emphasis in original). This imagination of data is articulated 'against the seamlessness of phenomena' (ibid). Within education, for example, data frame processes of teaching, learning and organising, and produce tangible and observable objects such as 'learning outcomes' or 'good schools'. Hence, from a process perspective data help to frame a phenomenon by demarcating boundaries in space and time and in doing so, make these phenomena observable and controllable. Data are hereby not merely representing social reality but rather produce it. For example, interpretations of data as representation of e.g. learning outcomes elicit particular social imaginaries of learning and teaching, and are as such deeply normative and political.

Over the past 8 years have the terms sociomateriality and materiality gained momentum and increased attention. Pivotal have been the works of STS-scholars Lucy Suchman (2007) and Karen Barad (2007). Within organisation studies and information systems research, in particular Wanda Orlikowski and Susan Scott have been advocates to adopt a framework that conceptualises the material and social as ‘constitutively entangled’ (Orlikowski 2010: 125) and ‘inherently inseparable’ (Orlikowski/Scott 2008: 456). Of great influence to these interpretations of technology was the idea of a social construction of technology (SCOT). From the mid-1980s a ‘turn to technology’ (Woolgar 1991) took place in the previous called social studies of science, exemplified by two seminal books: Social Shaping of Technology (MacKenzie/Wajcman 2003 [1985]) and The Social Construction of Technological Systems (Bijker et al. 1987). Through this turn an interest in technical objects arose as inscription devices (Latour/Woolgar 1986); technical objects became participants in the building of heterogeneous networks (Akrich 1992; Latour 1992). In media studies this move from technological determinism to social constructivism took place in the 1990s and became the dominant perspective by 2000 (Lievrouw 2014). Since then new media research—similar to studies in related fields—puts ‘an emphasis on social shaping, the shared or negotiated meaning of technologies, user studies, and technological systems as products and representations of culture’ (Lievrouw 2014: 22). In these frameworks is the social hence not made solely out of social ties but rather an association of materially diverse entities such as people, practices, artefacts, ideas, tools, and technologies (Latour 1988, 2004, 2007). Any distinction between the two terms is purely analytical.

Following this line of argument we have ‘to take materiality and sociomateriality seriously when studying work and social interactions involving technologies’ (Faraj/Azad 2012). Information technologies may be conceptualised as ‘sociomaterial configurations’ (Suchman 2007). Thereby the notion of configuration draws attention to the ‘imaginaries’ and ‘materialities’ that technologies ‘join together’ (Suchman 2012: 48). It is hence important to consider the ways in which imaginaries of ‘good schooling’ or good learning outcomes are inscribed in educational information infrastructures and as such configure the organisation of learning. Importantly do scholars distinguish between the physicality and materiality of objects which is particularly relevant to the study of digital artefacts such as software, algorithms, databases, code to name a few (Mackenzie 2006; Lievrouw 2014; Kallinikos/Aaltonen/Marton 2013; Leonardi 2010).

We would like to suggest Barad’s (2007) term apparatus as a useful concept for understanding the sociomaterial dynamics of digital assessment practices in schools. Barad (2007) understands an apparatus as a material-discursive, boundary-drawing practice. Such practices ‘are understood as specific material reconfigurings through which “objects” and “subjects” are produced’ (2007: 148). Apparatuses are ‘specific material (re)configurings of the world—which come to matter’ (2007: 140). In this respect may digital assessment practices (and associated educational information infrastructures and information systems) be seen as a way of performing particular orderings, of producing, e.g., particular learning and teaching subjects. Understanding ‘agential cuts’ (Barad 2007: 140, 381) is mandatory for understanding the effects of particular configurations. Karen

Barad (2007) is one of the most prominent scholars proposing a radical departure from our common ontological and epistemological assumptions. She argues that

> [h]umans enter not as fully formed, pre-existing subjects but as subjects intra-actively co-constituted through the material-discursive practices that they engage in (Barad 2007: 168).

Accordingly, the division between human and non-human actors cannot be taken for granted; boundaries are enacted through 'agential cuts' (Barad 2007: 381). Barad illustrates this 'cut' with the example of a person holding a stick. It can be said that the stick is either being observed by the person holding it (feeling its thickness, material, texture) or may be used to observe the surroundings (for example if the person is in a dark room and uses the stick to guide them). An agential cut is being made, so Barad, between the 'agency of observation' and the 'observed object': In the first instance, the stick is the observed object; whereas, in the second instance, it is part of the agency of observation (a cyborg observer). Hence the boundaries and properties of component parts of any given phenomenon are only determined through the 'agential cut' that delineates what is the 'measured object' to what is the 'measuring agent' (Barad 2007: 337). It follows that when boundaries are cut, objects/subjects are enacted intra-actively. What is of interest is to see how, when, and why 'agential cuts cut things together and apart' (p.381); how boundaries are performed.

Overall Barad (2007) argues that we should rather perceive phenomena that we encounter as a 'nondualistic whole' (p.206) as it does not make sense to talk about independently existing entities within, behind, or as causes of these phenomena (cf. Barad 2007: 205). Rather, such entities only exist in relation to each other within a phenomenon, as 'relata-within-phenomena' (p.139), produced through their 'intra-action' (p.33). Hence, relata do not pre-exist their relation: They do not have an independent existence outside their relationship or intra-action. Only through association do they take form and shape, and become particular or specific subject- or object-orderings.

> It is through specific agential intra-actions that the boundaries and properties of the components of phenomena become determinate and that particular concepts (that is, particular material articulations of the world) become meaningful (Barad 2007: 139).

Subsequently because objects are inherently relational effects, this means that the change in relationship changes their very figuration: Relata are coalesced in their relationship. Boundaries (e.g. human-non-human) are enacted with respect to the configuration the relationship affords. In order to accommodate these considerations, several IS scholars (e.g. Orlikowski/Scott 2008, Introna 2013, Faraj/Azad 2012) have turned their attention to the practices, doings, and actions that form translations and orderings. For example, Introna (2013) argues that 'process and performativity is fundamental to our understanding of the sociomaterial' (p.330). Therefore, sociomaterial research—following Barad's agential realism—is interested in processes in the performances of associations, their relations and participating entities, and hence in the performances of objects, subjects, practices, ideas, discourses, architectures or plans. In the following we will juxtapose three case studies that exemplify the increasing importance of data in educational practice. They are not meant to represent different degrees of increasing datafication but rather are we interested in exploring what a sociomaterial approach offers when analysing digital assessment practices. We will conduct our analysis by focusing on the ways in which these data practices and their associated apparatuses constitute learning and teaching subjects differently.

3 Case studies: Datafying education

In this section we present three case studies through which we want to illustrate some of the effects of the increasing datafication of education, in particular digital assessment practices. The case studies start off with a focus on how digital assessment practices and related assessment data ‘represent’ a students’ learning outcomes. The second case study demonstrates how this data is then used—not for representing a student’s abilities—but for representing a teacher’s pedagogical qualities. Through complex algorithms is student test data used to calculate the ‘added-value’ of a given teacher/school/district to a student’s/class’ learning success. While these case studies are examples of descriptive apparatuses the third case study presents a recent initiative at IBM to develop prescriptive algorithms which aim to anticipate the future performance of students (rather than describe how well students have performed a task or acquired certain skills).

3.1 Student assessment and digital data practices

In 2001 the New York City Department of Education (the largest education system in the USA) contracted the Grow Network to provide a data-driven decision-making tool to teachers, district and school instructional leaders, serving approximately 1,200 schools. The Grow Network offers teachers support in analysis and decision-making. It was linked to instructional materials and resources for teachers suggesting activities and teaching strategies in order to improve standards-based learning in the classroom. One of the authors was involved in a research project that studied the Grow Network. The research included ethnographic research in 15 schools in which 45 semi-structured interviews with principals, assistant principals, staff developers and teachers were conducted.

The explicit goal of the project was ‘to help teachers to collect more course material and rethink their classroom organization’ (Breiter/Light 2006: 212). After the introduction of the Grow Network the apparatus for teachers’ decision-making changed, and made a difference to their own assessment. For example, teachers said that they used the data to know ‘where their students are’. The ‘where’ was set in relation to other classes, schools, districts, countries—depending on the aggregation level. Importantly digital assessment practices made ‘a difference to who, what and when things are included or excluded’ (Orlikowski/Scott 2012: 129). For example, teachers realised that students’ were tested against standards and skills that they were not teaching and adjusted their teaching to the standards inscribed by the tests. Breiter and Light (2006) write that the reports ‘helped teachers align their teaching to what the state standards expect children to be able to know and do’. Some teachers realised that their pupils scored low on a particular skill, because of the way in which they taught this skill or that they were not teaching to the standards and skills on which the students were tested. In addition teachers reported that they ‘loved’ the material that was offered on the Grow Website in order to support their students in the acquisition of ‘missing skills’ (see figure 1 in the appendix).

The test results were hence not merely a ‘representation’ of what a student knew but rather invited teachers’ to reflect upon their own teaching. The reports were seen as additional information to their daily interactions with their students. The test results provided an additional source of information, which was insufficient as sole basis for decision-making; teachers always compared student data with other information (such as their own assessments, observations, conversations and also discussions with colleagues). Some teachers noted that they shared the information with their students (and their parents) and hence transformed the test results into an engagement tool.

The apparatus hence works as a specific configuration of data, online system, teachers, parents and the school district to produce particular learning subjects. The data practices of teachers (e.g. interpretation of test results) are complex and boundary spanning as they are also employing other types of information for their decision-making. The data are hence only meaningful in relation to practices outside the digital assessment apparatus such as observations, conversations between teachers, students and parents.

3.2 Teacher value-added

Anybody that has ever taken a test knows about the volatility of the results. Above, we have pointed to the fact that teachers realised through the Grow reports that they were not teaching certain skills in the ways in which the standardised curriculum prescribed them to do. In order to 'adjust' for this 'unfair mismatch' the idea of value-added was introduced. Here the apparatus does not assess between classes or schools or districts but rather the 'learning curve' within the same cohort. This approach promises to overcome certain prejudices and the fact that, depending on the socioeconomic background of parents, pupils have very different starting points. What should be compared are hence not the results per se, but rather the added-value of a particular teacher or school.

The system is based on data which is gathered from standardised student achievement tests, re-combined with socio-demographic and other data in sophisticated algorithms to calculate so-called 'teacher value-added'. This indicates the progress children have made in learning. It is compared between the grade levels of students and the difference is assigned to the quality of a teacher's teaching. Superintendents define goals for the schools, and school principals for their teachers. This data-driven system builds the basis for incentive-based salaries. In some areas, the results are published online, allowing anybody to check the so-constructed 'quality' of a teacher. In order to process the data, districts and states have built large-scale information systems as data warehouses to support decision-making. Given this, the 'impact' of the school can be measured, taking into account that the goal is to increase the overall performance (in standardised tests).

In the U.S. the idea of value-added was strongly linked to the Education Act 'No Child Left Behind' of 2001 to improve American education. States had to demonstrate 'yearly progress' in improving student test scores in order to receive funding (Sunderman/Kim 2005). As teachers are the most influential factor (as extensively documented by the meta study of (Hattie 2009)) for learning outcomes, but not the only one, the statisticians included additional factors in their formula (see figure 2 appendix). In many U.S. school districts this resulted in policies that partly determine a teacher's, principal's and superintendent's salaries based on data.

Besides this national and State level of educational governance, school regions started to incentivise district superintendents with bonuses for better test scores (Winerip 2011). The districts passed this bonus on to principals in order to 'honour' their school's progress. The (currently) final development are rankings of schools and teachers based on the value-added results. In the second largest district in Los Angeles, the local newspaper offers an online service to search for schools and teachers to check for their added value per grade level and subject (see figure 3, appendix).

Similar to the apparatus described in the first case study, data practices associated with value-added do not just represent but rather produce learning- and teaching-subjects. Yet, the subject position of the teacher is shifting from an observer and interpreter of data, from somebody that acts with data to somebody whose work practices are observed and interpreted, somebody who is acted upon. The data are detached from the teacher’s situated observations and conversations with students and parents. In addition, in such a system the test results of any student are not only representing the student’s qualification but are always put in relation to the results of their peers. As already established in the Grow Network study (#1), assessment practices that evaluate amongst teachers, schools or districts have direct consequences on the ways in which teaching is organised and learning subjects are constructed. For example, students with test scores on the edge between pass and fail (or below and above standards) were treated with increased attention (so-called ‘bubble kids’) because improving their scores had a higher impact on the overall performance than improving top performers or mediocre students.

The material-discursive data practices hence perform different ‘cuts’ and subsequently produce different teaching and learning subjects, but also different ways about what is knowable and observable about teaching and learning outcomes.

3.3 IBM Watson not only description but prescription

The last case study performs yet another cut and hence again different learning and teaching subjects are co-produced through data practices. The case study concerns IBM’s newly launched initiative called ‘education for a smart planet’. Part of this initiative is the promise of developing a ‘smart classroom’ that overcomes issues related to a ‘one-size-fits-all model’. Within the next five years aims IBM to develop a ‘smart classroom’ that provides a ‘truly personalized environment’.

With the IBM Smart Classroom, a syllabus is promised that will be created ‘based on individual learning style and pace. Not on an arbitrary teaching schedule’. The boundaries of the apparatus are shifting again. The ‘arbitrary teaching schedule’ which is currently the implementation of a standard curriculum is being set in relation to the needs and skills of any particular student as analysed by the system. The wording suggests that the system is able to ‘represent’ a student’s abilities. These abilities are constructed as a set of skills relative to the assessment practices of IBMs information infrastructure, and hence establish new cuts. It is not the teacher anymore that relates test results to standard curriculums (#1) or the governing bodies that abstract from these skills (#2) but rather complex algorithms that determine degrees of ‘representation’ and in doing so produce ‘learning outcomes’. Williamson’s (2015) ‘governing software’ and ‘algorithmic power’ hence become decisive actors in the production of the social imaginary of good schooling through the ways in which they reconfigure the organisation of learning.

As such, assessment practices have always been an important aspect of education. Yet through digital assessment practices and the ever increasing importance of educational information infrastructures (and associated algorithms), has changed the organisation of learning profoundly and will continue to do so. IBM states that the ‘the classroom of the future will learn about individual students over the course of their education and help them master the skills critical to meeting their goals’ (IBM 2015). Within this apparatus the individual student is rendered and produced as a learner that is observed and observable throughout their education, and each account builds on the previous step. The learning subject, in turn, becomes rendered predictable and passive:

A system fuelled by sophisticated analytics over the cloud will help teachers identify students who are most at risk, predict their roadblocks and then suggest measures to help the overcome their challenges (IBM 2015).

In IBM's smarter classroom the learning subject is co-constituted and co-produced through learning algorithms; an adapted curriculum in turn reinforces these algorithms. These things matter as they have real consequences on the ways in which children are being taught, what they are taught and how they perceive of themselves as learners. The teaching subject is likewise constituted differently—as an association of the physical and embodied teacher entangled in a web of data, smart devices and algorithms to support the 'ideal learning outcome'.

3.4 Discussion

The case studies above allude to a development in which the classroom transforms from a physically bound place with a teacher's grading book into a transparent and distributed space. The boundaries of the apparatus shift as the doings within a classroom are seemingly translated into the digital realm and 'represent' a student's, teacher's or school's accomplishments. The students themselves become part of an ever improving algorithm that 'learns the students' and by doing so learns itself (learning analytics). In addition, the learning child comes to know about itself by relying on the 'knowledgeable' algorithm. It is not through social interaction with the teacher and other students that students learn about themselves and how others judge their academic and social skills but rather a black-boxed, almighty algorithm learns about them and 'knows' them since their early childhood. These algorithms or 'calculative practices are enacted as technologies of governance' (Introna 2015) as they govern a child's learning, classroom organisation, teacher and school performance. The learner becomes governed by data and software (Williamson 2015), children grow up constituted as learners through 'algorithmic power', accountability is shifted to the system as it knows best and predicts any future development.

All three case studies have provided evidence that educational information infrastructures configure different learners than traditional classroom settings. Case studies #1 and #2 are both based on the same data: student achievement tests; yet they involve different actors that interpret the data (1) differently and (2) for different means. Subsequently the actions upon these data differ and reconfigure the organisation of learning differently, they enact different learning and teaching subjects. For example, in case study #1 the teachers interpret the data in order to enrich their own classroom observations, in case study #2 the data do not solely stand for the students' achievements but rather they 'represent' the achievements of teachers (value-added) and are interpreted by school administrators or parents. Case study #1 emphasised the aim to improve schools and support parents and teacher with respect to what can be done in support of any particular child. These efforts were equally distributed amongst pupils and facilitated individual support. Yet, as demonstrated in case study #2, the same data may be used to follow on different objectives such as increased accountability or transparency. The data are employed as control instruments that allow for the 'observation' of a teacher's or school's performance. In this scenario, the individual students' achievements are not interpreted in order to support their individual learning, but rather those students come to be of interest who make the biggest difference to the overall performance/ranking of a class or school. It is in the interest of a teacher or school to pay special attention to those children as a slight increase or decrease in their performance has e.g. consequences for the number of students failing or passing, or the number of students achieving excellent grades and continuing at prestigious further education institutions.

This output-orientation goes hand in hand with increased control (governance) of school systems (Behn 2003), also based on neo-liberal reforms (new public management, (Pollitt/Bouckaert 2000)) and data availability beyond imagination. As Anagnostopoulos et al. (2013) argue: The original intention to support the improvement of schools has been diminished by the sudden realisation that it also provides an effective control instrument; they have become ‘infrastructures for accountability’.

Hence, the ways in which data rank students and their achievements matter as they are not mere representations of a student’s or class’ performance but rather are interpreted and acted upon. When teachers increase their attention to those students whose test scores are at the margins between pass or fail, who statistically make a difference to the overall performance of the class, then the teaching and learning subjects come to be constituted differently. Hence, following Barad (2007) it can be argued that it does not make sense to talk about learners or teachers as independently existing entities, rather they come to be produced through their ‘intra-action’ within particular sociotechnical apparatuses (in our case digital assessment practices). The ‘individual learner’ as such does not exist but only ‘learning subjects’—performed and constituted through particular imaginaries of good schooling, through the performance of assessments, the collection and interpretation of assessment data, the acting-upon these interpretations. All these practices come to constitute teaching and learning subjects.

Hence, the apparatuses in and through which teaching and learning subjects are co-constituted and co-produced are being reconfigured through transforming material-discursive data practices: The ways in which IBM’s future Smarter Classroom and current digital assessment practices configure learning subjects can be conceptualised as the performance of sociotechnical apparatuses which configure educational assessment not as human-based activities but rather as specific material-discursive practices. These material (re)configurings of the world differently enact social realities, e.g. with respect to what is meant by ‘good schooling’ or a ‘good teacher’ and how such imaginaries come to be enacted.

4 Conclusion

In this paper we have attended to the ways in which digital assessment practices reconfigure the organisation of learning. We drew attention to the ways in which sociotechnical apparatuses join together imaginaries (of e.g. ‘good schooling) and materialities (of e.g. data based on student achievement tests), and in doing so produce new subject and object positions for learners, teachers and educational managers. We demonstrated that this has important political and ethical consequences because the ways in which such technologies constitute the organisation of learning is not value-neutral. Data and associated algorithms are never given or raw, but always produced within particular social imaginaries about learning and education. They structure the ways in which classrooms and teaching are organised, and as such articulate our changing imaginaries of 'good schooling', learning and teaching.

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6 Appendix

PIC 1

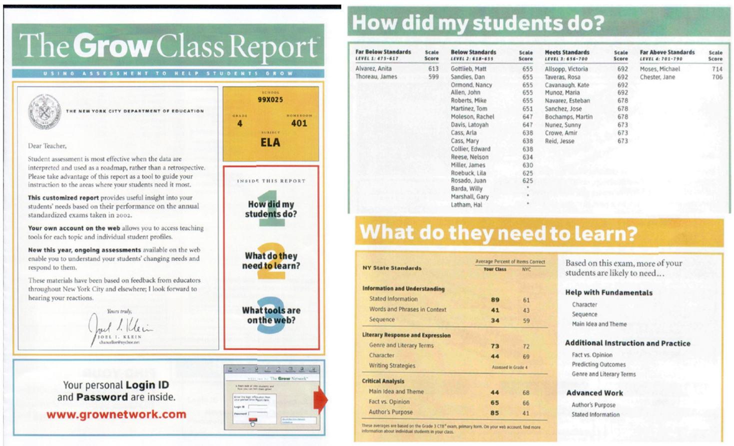

Figure 1: Source: Author paper copy of Grow reports

PIC 2

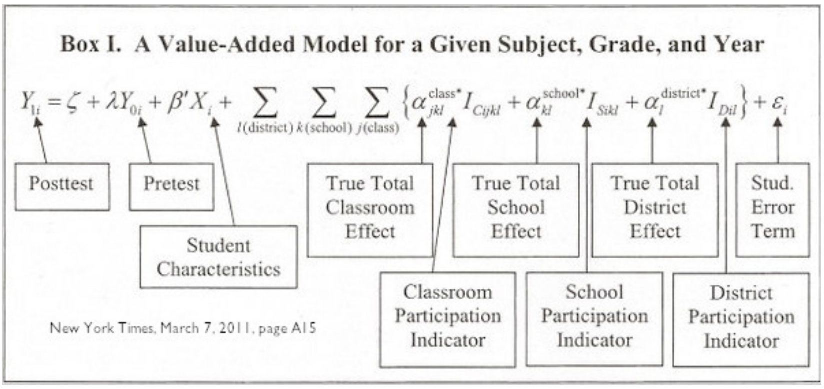

Figure 2: Source New York Times, 7th March 2011

PIC 3

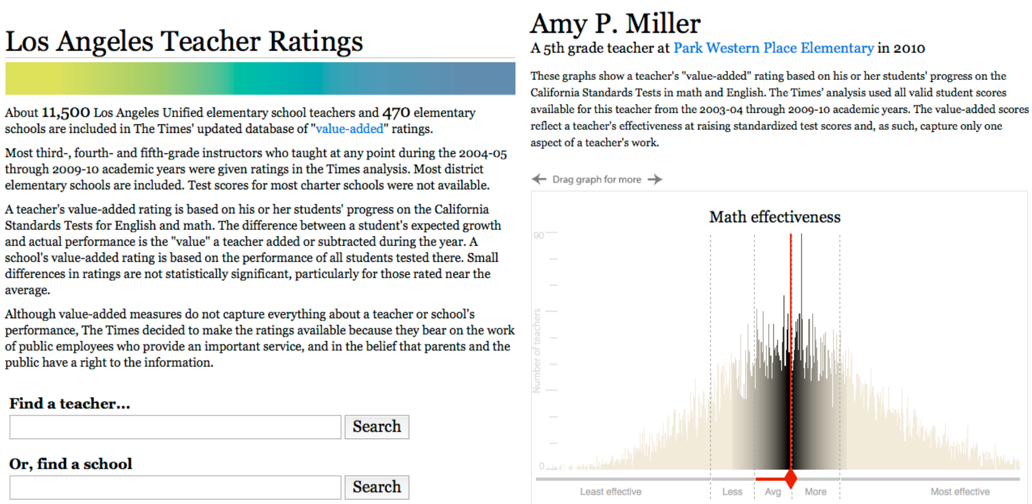

Figure 3: Source: www.projects.latimes.com/value-added